INSECT COLONIZATION OF DRILLED TREE HOLES[1,2]

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ABSTRACT: Beginning in 1978 January, and continuing over a 18 month period, 30 drilled holes in the West Virginia University Forest, Coopers Rock State Park, Morgantown, West Virginia were sampled to determine species of colonizing insects. Insect colonizers included four species of Culicidae, one species of Syrphidae, and undetermined species of Trichoceridae, Ceratopogonidae, and Helodidae. Numbers of individuals flucuated widely both with time of year and from site to site. Colonization was typically initiated with retention of water or damp detritus material in a previously dry hole. Following moisture loss, insect habitation was very limited.

Tree holes provide a unique and specialized abode for breeding by many insects, other invertebrates and vertebrates. Competition for existing sites is intensive and environmental conditions may make some tree holes unavailable for use. Increasing the number of tree holes in an area could relieve some of this intra- and interspecific competition for existing breeding sites. The United States Forest Service is studying the effectiveness of drilled holes in three tree species to accelerate den formation for various squirrel species (Sanderson & Michael, 1975)[4]. While some drilled holes were utilized by squirrels, a large number were retaining a high level of moisture making squirrel habitation impossible, but increasing probability of insect habitation. Tree holes vary from dry, to damp, to wet (standing water). Each habitat supports different, and sometimes predictable, insect colonizers which require specific habitats. Wood-boring insects are found in dry holes; fungus-feeding insects in damp, fungus-containing holes; and mosquito, syrphid and ceratopogonid larvae in wet tree holes. The insect families Culicidae and Ceratopogonidae include

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many species that are annoying to man and livestock because of their bloodsucking habits. Some species of tree hole breeding mosquitoes are important disease vectors.

Among those who have studied the ecology and biology of tree holes are Kitching (1971) and Smith and Trimble (1973). Numerous reports are available on specific tree hole inhabitants, especially mosquitoes. Fairly complete information about the occurrence of mosquitoes in tree holes exists for many parts of the world and faunal lists have been produced.

Methods and Materials

The study area was a mixed stand of hardwoods, primarily oaks and maples, on a sloping ridge at an elevation of 788 meters. The site is located in the West Virginia University Forest at Coopers Rock, Monongalia County, West Virginia.

From 1975 September to 1976 December the U.S. Forest Service (USFS) drilled 192 (numbers 001-192) tree holes equally divided among *Acer rubrum* L. (red maple), *Quercus alba* L. (white oak) and *Q. rubra* L. (red oak). An electric drill powered by a portable generator was used to form a triangular cavity about 8 cm on a side and approximately 15 cm deep. Elevation of holes averages 7.7 meters above the forest floor.

Every fourth tree was selected to divide each tree species into four groups with relatively equal diameter at breast height distributions. Each group was randomly selected for treatment [drill only, drill plus glycerol (100 cc), drill plus fungus, and drill plus glycerol (50 cc) and fungus]. Glycerol was added as a substrate for fungal growth to determine if the tree hole decay could be accelerated.

Fungal cultures, obtained from Dr. F. Berry, Northeastern Forest Experiment Station, Delaware, OH. were tree species — specific as follows:

red maple inoculations — *Inonotus (=Polyporus) glomeratus* (Pk.) Murr.
northern red oak inoculations — *Phlebia chyrsocrea*
white oak inoculations — *Polyporus compactus* Overh.

From the 192 trees drilled and otherwise treated by USFS personnel, 30 trees were randomly selected for insect sampling without regard to tree species or to the four treatments mentioned above. 192 paper slips, numbered 001-192, were placed in a circular bin, mixed, and 30 slips were chosen. The results produced 11 white oak, 4 red oak and 15 red maple tree holes to be monitored for insect activity. At the location of the drilled holes the tree trunks were approximately perpendicular to the ground. Tree holes were examined on each of the following dates: 12 May 1978, 24 August 1978, 14 November 1978 and 10-12 April 1979. The author attempted to obtain a sample on a date that corresponded to each of the four seasons of a year.

Access to tree holes for sampling was obtained by use of two 3.4 meter sections of Swiss® ladders secured to the tree. A harness was used which provided safety and allowed freedom of movement during the sampling process. Collection equipment included suction pipettes, forceps, teaspoon, flashlight and several two dram vials placed in a shotgun shell belt secured around the waist. On each sampling date any liquid samples which contained insect larvae or any adult insects collected were returned to the laboratory for further examination.

Insect larvae removed from water-filled tree holes were returned to the laboratory intact in their aquatic media for rearing. Because of the fluctuating water levels in a tree hole during the year, only 10-15 ml of liquid was removed, so as not to hasten water loss within that hole. The sample liquid was mixed with 10-15 ml of distilled water and placed in a 50 ml beaker with finely ground Purina Lab-Chow® added as larval food. Plastic wrap secured over the beaker has a three-fold function: (1) prevented formation of a surface film that would hinder the respiration of surface-breathing larvae, (2) prevented evaporation and (3) maintains a constant internal temperature. Beakers were placed in an environmental chamber with a 12-12 hour photoperiod and at 28°C temperature.

Results and Discussion

Sampling results for each of the 30 tree holes utilized in this study are presented below. Trees of each of the three species are listed according to tree number (001-192) as designated by USFS researchers. Following the general results and discussion, each tree species will be discussed as to its suitability for insect habitation.

White Oak – *Quercus alba*

#029 — cavity exposure (cav. exp.) WSW. No insect observed (NIAO) dry hole (DH).
#035 — cav. exp. WSW. NIAO. DH.
#131 — cav. exp. E. NIAO. DH.
#173 — cav. exp. ESE. NIAO. DH.
#41 — cav. exp. ESE NIAO. DH.
#42 — cav. exp. ESE. NIAO. DH.
#180 — cav. exp. ESE. 12 May: water in hole and *Aedes triseriatus* (Say) (Diptera: Culicidae) larvae were collected and reared. At other sampling periods the hole was dry and no additional insect species were present.
#183 — cav. exp. ESE. NIAO. DH.
#186 — cav. exp. SSE. NIAO. DH.
#190 — cav. exp. NNW. NIAO. DH.
#191 — cav. exp. W. NIAO. DH.

Red Oak – *Quercus rubra*

#10 — cav. exp. SSE. No insect activity observed; dry hole.

#124 — cav. exp. NNW. No insect activity observed; dry hole.

#163 — cav. exp. SSW. 12 May: water was in the hole and several larvae of *Eristalis* spp. (Diptera: Syrphidae) were collected. Attempts to rear to adults failed. Further collection results were negative; the hole had dried up.

#34 — cav. exp. SSE. 12 May: *Eristalis* spp. were collected. On 10 April the hole was damp and larvae of Ceratopogonidae and Trichoceridae (Diptera) were collected.

Red Maple – *Acer rubrum*

#14 — cav. exp. N.NIAO.DH.

#27 — cav. exp. SSW. 12 May: larvae of *Erisalis* spp. and *Ae. triseriatus* were collected. Further collection results were negative, the hole had dried out.

#107 — cav.exp.N.14 Nov: the hole was filled with water and larvae of *Orthopodomyia alba* Baker (Diptera: Culicidae) were collected. This is the first time this mosquito species had been collected in the state of West Virginia (Heaps, 1980). On 12 April, the hole contained only damp detritus; a teaspoon of this was collected and re-hydrated with 30 ml of distilled water back in the laboratory. This detritus contained diapausing eggs of *Ae. hendersoni* Cockerell (Diptera: Culicidae). The dozen larvae that hatched from these eggs were reared. *Ae. hendersoni* is a rare species in West Virginia, only once previously collected Amrine & Butler, 1978).

#113 — cav. exp. SSE. 24 August; larvae of *Ae. triseriatus* and Ceratopogonidae were collected. 14 November: larvae of *Eristalis* spp., Ceratopogonidae and 3 adult helodid beetles (Coleoptera: Helodidae) were collected. 10 April: the hole was dry.

#125 — cav. exp. S. NIAO.DH.

#16 — cav. exp. SSW. NIAO.DH.

#148 — cav. exp. S. 24 August: larvae of *Eristalis* spp. and *Ae. triseriatus* were collected. On 10 April, the hole was inhabited by a flying squirrel thus preventing any further sampling.

#150 — cav. exp. SSW. 14 November: larvae of *Eristalis* ssp. Ceratopotonidae and 2 adult helodid beetles were collected. Further collection results were negative.

#6 — cav. exp. W. 24 August: one adult female *Ae. triseriatus* was collected.

#112 — cav. exp. WSW. 24 August: larvae of *Anopheles barberi* Coquillet (Diptera: Culicidae) and Ceratopogonidae were collected.

#134 — cav. exp. WSW. NIAO.DH.

#135 — cav. exp. SSW. NIAO.DH.

#138 — cav. exp. S.NIAO.DH.

#139 — cav. exp. SSW. 24 August: 2 larvae of *An. barberi* were collected and reared.

#145 — cav. exp. S. 24 August: 4 larvae of *Ae. triseriatus* were collected and reared.

Kitching (1971) defines a tree hole as any cavity or depression existing in or on a tree and divides them into two distinct categories. First, there are those tree holes which continually maintain an unbroken tree lining and secondly, those which lack this lining and penetrate through to the sapwood and, ultimately, to the heartwood of the tree. The first of these categories may be referred to as "pans" and the second as "rot holes".

Rot holes require some external agent for their initiation. For this reason, the tree holes used in this study fall into this category. Initial damage to the bark was made by drilling of the holes. If environmental conditions allow fungal growth, a subsequent enlargement of the hole by rotting occurs.

Within the current study area three distinct types of tree hole habitats were found. they are: (1) dry holes and dry detritus, (2) holes containing damp detritus but no standing water and, (3) holes with standing water plus detritus. Insect activity was most evident in water-filled tree holes as they served as insect larval habitats; activity is much more limited in drier holes.

Of the tree species studied, red maple is most suitable for insect habitation. The following species of mosquito larvae were found in red maple tree holes during the study: *Aedes triseriatus,*(Say),*Ae. hendersoni* Cockerell,*Anopheles barberi* Coquillet and *Orthopodomyia alba* Baker. No tree hole was found to contain more than one mosquito species at any one time or more than three species of colonizers. Also collected from red maple tree holes were larvae of *Eristalis* spp. and Ceratopogonidae, and adults from the coleopteran family Helodidae.

In this study red maples held water more efficiently than either white or red oaks. However, any one of the three species could provide the necessary requirements for insect habitation if the moisture level remained sufficient for the time needed for the insect to complete its life cycle. Some factors which limit this moisture level in a tree hole are: cavity exposure, inclination of the tree from vertical, rainfall, temperature and the ability of the tree to resist internal and external cracking. The height of the tree hole above the forest floor may influence the composition of the insect fauna present. Common forest floor insects with limited locomotion would have difficulty gaining access to higher tree holes.

The results indicate that holes should not be drilled in red maple in an attempt to increase and accelerate den formation for various squirrel species. Red maple tree holes accumulate water for extended periods of time making vertebrate habitation impossible. Oak trees, especially white, would be an acceptable alternative as a solution to this problem.

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